TYPE II PROGRESS REPORT NO. 1 TYPE I PROGRESS REPORT NO. 3 UNIVERSITY OF TENNESSEE AGRICULTURAL REMOTE SENSING APRIL 9, 1973

(a) PROJECT TITLE: Utilization of ERTS data to detect plant diseases and nutrient deficiencies, soil types and moisture levels.

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- J. C. Rennie (Forestry)

- (b) GSFC ID UN650 MMC #139, Contract No. NAS5-21873
- (c) The main problem has probably been cloud cover over test areas. Only two sets of imagery have been received for two test sites (Nos. 3 and 5) and in each case, one set of imagery had considerable cloud cover. Thus, the report herein includes data from only 1 set of imagery at these two test sites. Support aircraft imagery was off slightly at test site 5 but has been reflown. Other normal deterrents such as computer turnaround time, computer down time and scanner down time have served to delay certain phases of work at times.

In view of our unsuccessful attempts to obtain "GSFC Specification S-250-P-1C, March 1972, titled Contractor-Prepared Monthly, Periodic and Final Reports" which states the format for Type II progress reports, this report has been prepared using the format of Type I progress reports.

- (d) Accomplishments
 - 1. Delineation of Soil Associations: (Parks)

The delineation of soils through the use of aircraft imagery has been accomplished by several investigators. Even specific soil types have been identified using low altitude aircraft imagery. As the altitude of the sensor increases, the soil delineation process becomes more macro. Thus, the larger soil associations may be detected at altitudes similar to that of ERTS.

Identification of soil association is much easier if the soil has been recently tilled and preferably void of vegetation. However, it is possible to delineate soil associations that have vegetative cover where the type of vegetative cover is fairly uniform and consistent with the particular soil association. The examples reported herein are cases of soil association delineation through the reflective characteristics of a fairly uniform vegetative cover. However, it should be remembered that a casual onsite observer might not consider the vegetative cover uniform as small areas of trees, bushes, and even small cultivated fields are scattered throughout the area. The ERTS sensors blends this reflectance with that of the more dominant type of vegetation.

The Memphis soil association has been delineated in Obion and Dyer counties of Tennessee and in Fulton County of Kentucky using Channel 7 of ERTS I imagery obtained on October 1, 1972.

Original photography may be purchased from: EROS Data Center 10th and Dakota Avenue Sioux Falls, SD 57198

This soil association occurs on the western edge of the loess that covers a large area east of the Mississippi river and extends from Kentucky to Louisiana.

A soil association map of Obion County and a black and white photograph of Obion County, adjacent counties and portions of Kentucky are shown in Figure 1. The large block of the Memphis association is located in the western half of the county. A smaller block of the Memphis association in the northwest corner of the county and extending into Kentucky is also visible on the photograph. Other identifying features in the photograph are the Mississippi River crossing the northwest corner, Reelfoot Lake located between the Mississippi River and the large block of the Memphis soil association. Union City is located northeast of the center of the photograph and Fulton, Kentucky is located in the upper right corner. The Obion River crosses the county, flowing in a southwestardly direction. The Waverly-Falaya-Swamp soil association that borders the Obion River is also visible.

Figure 2 shows a small section of the computer printout from the electronic differentiation of the Memphis soil association, the Adler, Convent, Falaya soil association and Reelfoot Lake along with a small section from the photograph in Figure 1 identifying the area in the computer printout.

Figure 3 shows another small section of the computer printout showing the Obion River, the adjacent Waverly-Falaya-Swamp soil association and a small section from the photograph in Figure 1 identifying the area in the computer printout.

A soil association map of Dyer County and a black and white photograph of the county and portions of surrounding counties is shown in Figure 4. The large block of the Memphis soil association is located near the center of the photograph and just below the Obion River. The Forked Deer River is in the lower half of the photograph and the Mississippi River borders the western edge of the county.

To date only 3 sets of imagery (13, Sept.; 1, October and 6, Nov.) have been received from this area. The 1, October imagery was of excellent quality and different areas within it are being analyzed. Most of the area between the large block of the Memphis soil association (Figure 1) and the Obion River will be plowed in April. Further efforts of aircraft and ERTS imagery evaluations are planned to determine the extent that the delineation of the smaller soil associations is possible.

2. Soil Moisture: (Sewell)

The target area under study is Ames Plantation in Southwest Tennessee. The target site is an area of 18,000 acres of which approximately 2,000 acres are under cultivation with the remainder in permanent pasture and forest.

Present efforts are directed toward correlating known ground truth data and associated information with ERTS imagery. Aerial photographs at 25,000 feet altitude, photographic enlargements of space imagery on the order of 4 X to 6 X, and ground field surveys are some of the techniques presently employed toward the accomplishment of this correlation objective. Some of the data collected on the target site from ground-level surveys follow: crop on field at time of satellite crossing, weather conditions, size of field, soil conditions on individual areas, extent of crop cover, and stage of crop maturity at each satellite crossing.

Aerial photos, imagery enlargements, and maps are used as aids in locating sites within the target area. Precise location of sites within target area has been difficult especially when the location is in an area which does not have a major definitely indentifiable landmark from which to work. Based on the imagery available to date, fields of 100 acres or less would appear to be very difficult to locate and study from space imagery. Areas which are larger than this are much easier to define and locate.

The digital scanning microdensitometer offers promise in locating the smaller areas. The microdensitometer quantitatively measures optical density of space-obtained imagery which is then recorded on computer tape. The resulting computer printout is, in effect, a 100 X enlargement of the scan area.

The computer time and labor involved in obtaining a scan printout presents a problem in that the entire campus system including memory banks must be made exclusively available to the scan printout operation. This results in excessive turn-around time.

From preliminary investigations, channels 5 (0.6 - 0.7 micrometers wave-length) and 7 (0.8 - 1.1 micrometers wavelength) appear to give the best results from microdensitometer scans for investigating soil moisture conditions. A much wider range of optical density values is found on this imagery as compared with channels 4 and 6.

Future plans are for more work in the area of signature development and the refining of scan printouts to give imagery which better enhances ground features. Another ground-level field survey of the target site will be conducted during the spring plowing season and at the time of the requested NASA-Houston ERTS-Support aircraft coverage. When more imagery is received, comparisons and further study will be made. In the meantime, further analyses of the available imagery are underway.

3. Plant Diseases: (Hilty)

Channel 7 of the Sept. 13, 1972, ERTS imagery is presently the most useful for our objectives --- crop discrimination. Features recognized on densitometer-computer output are rivers and flooded bottom land, row crops, pasture and timber. Of the row crops, corn and soybeans approaching senescense are most discernible on the fall imagery.

Ground information on stress due to diseases was not available when this imagery was obtained. Photographs of spring plantings are anxiously anticipated.

Very preliminary observations indicate imagery, particularly NASA underflight imagery, will permit crop identification, acreage estimates, and yield estimates. No comment can as yet be made concerning detection of disease stress.

An attempt will be made to plant considerable acreage of disease susceptible corn on Test Site 3 in Tennessee, to insure an expanse of disease-stressed plants for aerial photography.

4. Forestry: (Rennie)

In attempting to locate our test site on the October imagery, it quickly became apparent that certain useful features were observable on some bands but not on others. The following table is a subjective evaluation of feature resolution by band for the whole image.

| Feature | Band 4 Green | Band 5 Red | Band 6 IR-1 | Band 7 IR-2 |
|---------------------------------|-----------------|---------------|----------------|----------------|
| Water | 3 ^a | 2 | 1 | . 1 |
| Major highway rights-of-way | 2 | 1 | 3 | 3 |
| Terrain | 3 | 2 | 1 | 1 |
| Physiographic region boundaries | 1 | 1 | 2 | 3 |

- a: where 1 feature prominent and easily discernable
 - 2 feature of intermediate evidence
 - 3 feature difficult or impossible to observe

The determination of physiographic region boundaries was particularly interesting. Three physiographic regions are in the area covered by this set of imagery: the southern end of the

Appalachains, the Piedmont, and the Ridge and Valley Region. These three regions can be delineated on three of the four bands of ERTS-1 imagery; however, the features which accentuate the boundaries change with the band being observed.

On bands 4 and 5, land use appears to be the feature which defines the boundaries. In the mountainous area, farms and towns are few, resulting in a homegenous pattern; however, in the Piedmont and in the Ridge and Valley Region, there are numerous farms and populated areas resulting in a much dissected landscape pattern on the imagery. The definition of the boundary is particularly strong between the Ridge and Valley Region and the Appalachain Mountains because of the escarpment and the definite change in land use due to it.

On band 6, the relief of the mountains is evident on the imagery while the definition of land use if poorer. These two features combine to allow the boundaries to be located. However, the evidence of the boundaries is not as strong on band 6 as on bands 4 and 5.

On band 7, the definition of the mountain terrain increases and that of land use decreases resulting in very poor definition of the interregion boundaries.

In the vicinity of our test site, Polk County, Tennessee, there were two notable exceptions to the observability of features given above. First, on all bands of the imagery highway rights-of way are difficult or impossible to locate. This is attributed to the fact that in Polk County the highways, even U.S. 64, have narrow rights-of-way which wind through the mountains.

The second perculiarity in this test site is the presence of an extensive area of barren ground about five miles in diameter north of Copperhill, Tennessee (35°00' North, 84°22' West). This area appears as a dark spot on bands 4 and 5, and a light area on band 7.

Subsequently, two areas were located which have a similar response on bands 4 and 5 as the barren ground at Copperhill, Tennessee. These are the areas bordering Blue Ridge Lake (34°52' North, 84°15' West) and Lake Jocassee (34°55' North, 82°55' West). Initially these were interpreted as lake bed being exposed due to low water. According to T.V.A. water control records for 15 October 1972, Blue Ridge Lake had 2160 acres of water surface with 3330 acres possible. Surface area of water on Lake Jocassee was not available, but its elevation was 1010 feet on 16 October 1972, with the maximum elevation being 1110 feet.

Inquiries about the conditions of other T.V.A. reservoirs yielded information conflicting with the interpretation discussed above. In particular, Nottely Lake (about 12 miles northeast of

Blue Ridge Lake) had only 2380 acres of water surface of a possible 4310 acres. If the dark strips around Blue Ridge Lake and Lake Jocassee on bands 4 and 5 were barren ground, then a similar response should have occurred around Nottely Lake. Work will continue on trying to explain the differences between the responses of the different reservoirs.

Microdensitometer scans of the imagery have been produced for a 20,000 acre area north of Parksville Lake (35°8' North, 84°5' West). This portion of Polk County was chosen because of the availability of information on its forest types from the U. S. Forest Service. Prediction of forest types (pine, hardwood and pine-hardwood) was not attempted because of difficulties encountered in registering the computer output from the four bands.

(e) A significant finding to date is the delineation of the Memphis soil association in Obion County (Figure 1), Dyer County (Figure 4), and in portions of Kentucky (Figure 1). This soil association has delineated mechanically (Figure 2) through the use of imagery in the digital tape format, appropriate computer software and an IBM 360/65 computer.

The Waverly-Swamp association as well as the Obion River have been identified on the ERTS imagery as well as on the computer printout (Figure 3).

These findings demonstrate the feasibility of delineating major soil associations through vegetative cover common to the association. Channel 7 provides the most information for studies of this type.

Findings are shown on attached figures. Figure 5, a B & W negative print at 25,000 feet above ground level and made by NASA-Houston, gives a portion of Ames Plantation on 18 August, 1972. A lake (A) and a bend of the Wolf River Tributary (B) are outlined. The scale for Figure 5 is about one inch equals 0.77 mile. Figure 6, a channel 7 ERTS image of 1 October is a 3 X negative print of Ames Plantation and vicinity. The lake designated (A) has a maximum physical length of 1,860 ft. Wolf River Tributary is clearly visible in the ERTS image of Figure 6. The scale for Figure 6 is about one inch equals 5.13 miles. The water, wet areas, and flood plain of the wooded drainageway are represented by the lighter tones of the negative print.

Figures 7 through 10 give 4 X negative print enlargements of channels 4 through 7, respectively, for Ames Plantation. Figure 10 outlines the lake (A) and the area (C) shown as a computer printout in Figure 11. Channel 7 (Figures 6 and 10) best enhance water, while channels 4 and 5 (Figures 7 and 8) appear to delineate drainage patterns better than channels 6 or 7.

Figure 11 presents a negative optical density display of the computer printout for channel 7 (Figures 6 and 10). Scanning densitometer values

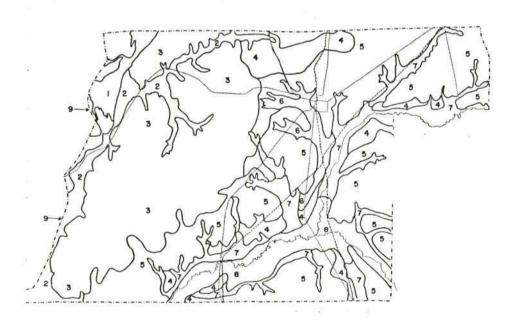
between 99 and 138 (of the 0-255 possible range of density values) are given in Figure 11. The area of the printout is denoted by (C) in Figures 6 and 10.

Computer density printouts assist markedly in making density separations and delineating major soil-moisture differences; however, signatures for soil-moisture classification for this area of mixed land uses in relatively small tracts have not yet been developed.

- (f) A paper entitled "Delineation of major soil associations using ERTS-1 imagery" was presented at the March 5-9 symposium on results from ERTS-1 sponsored by GSFC.
- (g) We hope that NASA aircraft support to ERTS investigators is continued. We find the group very cooperative and the information useful.
- (h) No changes in order forms have been made.
- (i)
- (j)



From ERTS-1, Obion County, Tennessee, 1, October, 1972



Obion County soil associations: 1. Bowdre-Sharkey, 2. Adler-Convent-Falaya, 3. Memphis, 4. Routon-Calloway-Center, 5. Grenada-Loring-Center, 6. Fountain-Dekoven, 7. Falaya-Waverly-Collins, 8. Waverly-Falaya-Swamp, 9. Iberia-Sharkey.

Figure 1. ERTS-1 imagery and soil association map of Obion County, Tennessee showing delineation of the Memphis soil association.



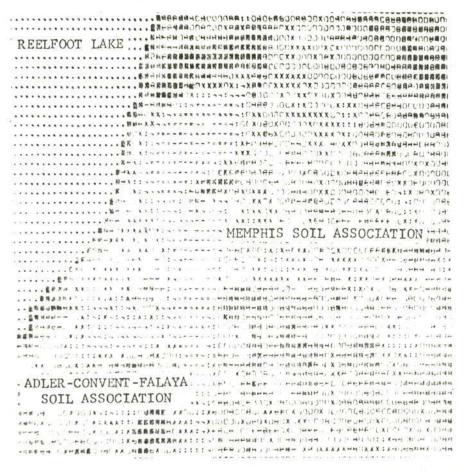


Figure 2. Photograph and computer printout from ERTS-1 imagery evaluation separating Reelfoot Lake, the Adler-Convent-Falaya, and the Memphis soil associations.

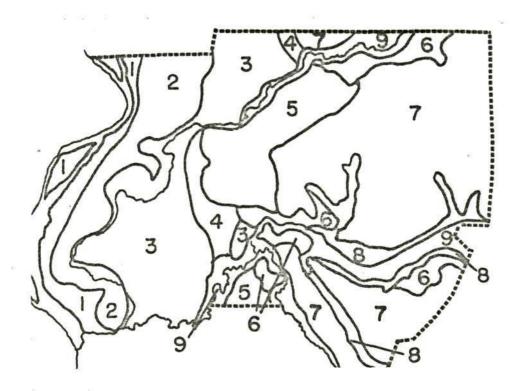




Figure 3. Photograph and computer printout from ERTS-1 imagery evaluation showing the Obion River and the adjacent Waverly-Swamp area.



From ERTS-1, Dyer County, Tennessee, 1, October, 1972



Dyer County soil associations: 1. Commerce-Robinsonville-Bowdre, 2. Sharkey-Bowdre-Tunica, 3. Alligator-Forestdale-Dundee, 4. Adler-Morganfield-Wakeland, 5. Memphis, 6. Routon-Calloway, 7. Loring-Memphis-Grenada, 8. Falaya-Waverly, 9. Waverly-Swamp.

Figure 4. ERTS-1 imagery and soil association map of Dyer County, Tennessee showing delineation of the Memphis soil association.



Figure 5. Black-and-white negative print at 25,000 feet of Ames Plantation vicinity on August 18, 1972. A lake (A) and the Wolf River Tributary (B) are outlined.

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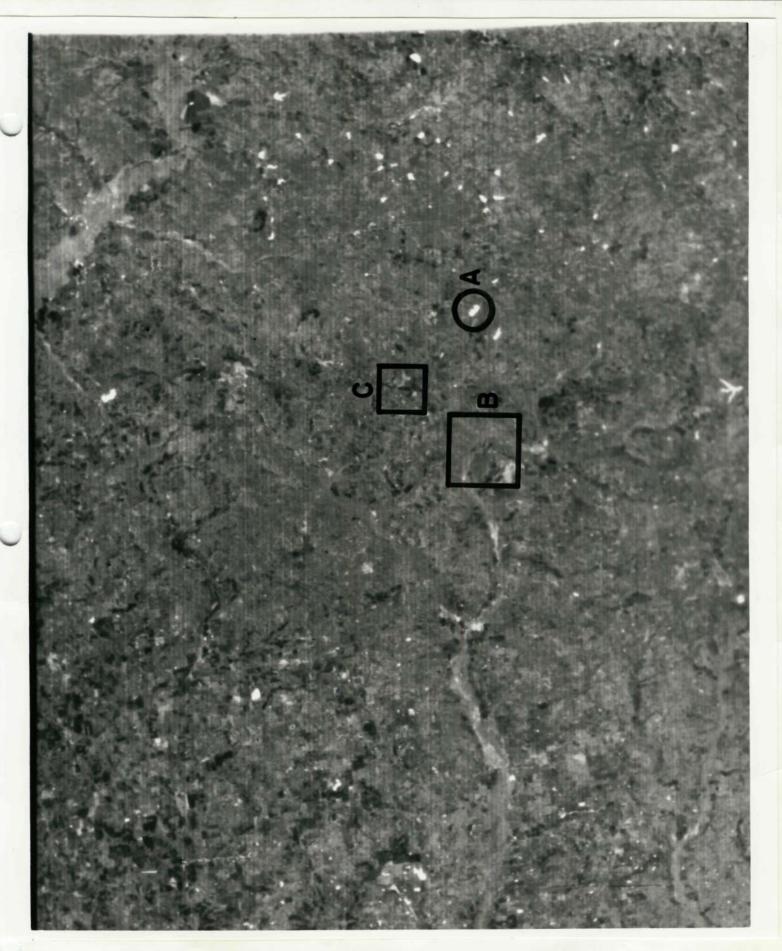


Figure 6. Channel 7 ERTS image of the Ames Plantation vicinity on October 1, 1972.

The lake (A), tributary (B), and area of computer density printouts (C) are outlined.

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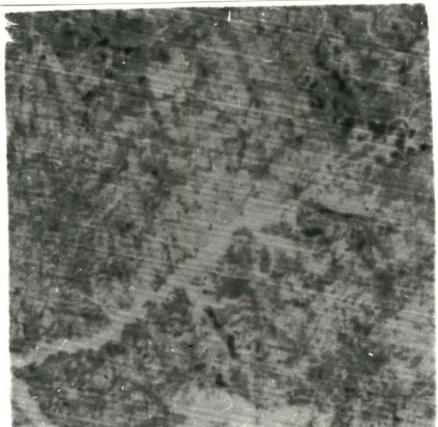


Figure 7. 4X enlargement of channel 4.



Figure 8. 4X enlargement of channel 5.

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Figure 9. 4X enlargement of channel 6.

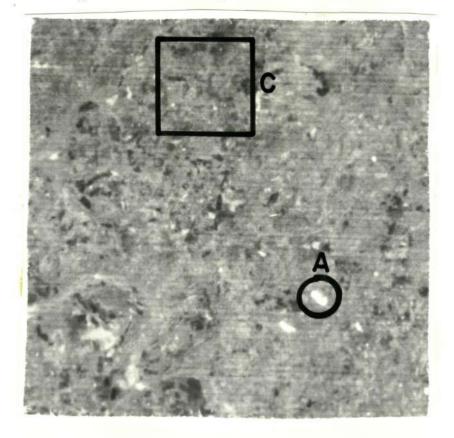


Figure 10. 4X enlargement of channel 7. The lake (A) and the area of computer density printouts (C) are outlined.



Figure 11. Channel 7 negative computer density display printout of test area (C) of Figures 6 and 10.